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The Teaching Gap

Best Ideas from the World's Teachers for Improving Education in the Classroom

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Preface

THIS BOOK IS ABOUT teaching and how to improve it. It is not another attempt to bash teachers or blame them for the ills that beset America's schools. It is also not another set of recommendations that tell teachers how to teach. It is, instead, a tribute to the importance of teaching, and to the key role that teachers must play in its improvement. School learning will not improve markedly unless we give teachers the opportunity and the support they need to advance their craft by increasing the effectiveness of the methods they use.

Our viewpoint arises from a collaboration that started more than five years ago. At that time, the Third International Mathematics and Science Study (TIMSS) was well into the planning stages. This study, the latest in a series of international studies stretching back more than thirty years,[1] compared mathematics and science achievement among students in forty-one nations. TIMSS was the most carefully designed international study of achievement ever conducted. One component of TIMSS was a video study that compared the teaching of eighth-grade mathematics in Germany, Japan, and the United States. The video study, on which we collaborated, marked the first time ever that national samples of teachers had been videotaped teaching in their classrooms. For the first time, we could see what teaching

actually looks like on a national scale, and we could do this for three countries.

Figuring out how to analyze and summarize these videos was challenging. But it also was a breathtaking experience. We often are blind to the most familiar aspects of our everyday environment, and teaching turns out to be one of these aspects. Looking across cultures is one of the best ways to see beyond the blinders and sharpen our view of ourselves. As we looked again and again at the tapes we collected, we were struck by the homogeneity of teaching methods within each culture, compared with the marked differences in methods across cultures.

Readers who are parents will know that there are differences among American teachers; they might even have fought to move their child from one teacher's class into another teacher's class. Our point is that these differences, which appear so large within our culture, are dwarfed by the gap in general methods of teaching that exist across cultures. We are not talking about a gap in teachers' competence but about a gap in teaching methods. These cross-cultural differences in methods are instructive because they allow us to see ourselves in new ways.

But the teaching gap we describe refers to more than cross-cultural teaching differences. It refers to the difference between the kinds of teaching needed to achieve the educational dreams of the American people and the kind of teaching found in most American schools. Although many of the American teachers we observed were highly competent at implementing American teaching methods, the methods themselves were severely limited.

The teaching gap becomes even more significant when one realizes that while other countries are continually improving their teaching approaches, the United States has no system for

improving. The United States is always reforming but not always improving. The most alarming aspect of classroom teaching in the United States is not how we are teaching now but that we have no mechanism for getting better. Without such a mechanism, the teaching gap will continue to grow.

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This book started out as a description of teaching in different cultures based on the data we collected in the video study. As we wrote the book, however, these differences in teaching methods turned out to be only part of the story. Equally important are the general truths we came to understand about teaching and the implications of these truths for the improvement of classroom teaching. Thus, although this book was initially intended as a report of the TIMSS video study, it quickly became much more than that. We do describe mathematics teaching in Germany, Japan, and the United States. But we also examine current reform efforts in the United States, and based on what we learned about teaching and about learning to teach, we propose a new plan for improving classroom teaching in the United States. Because the video study focused on eighth-grade mathematics, most of the classroom examples we present are from eighth-grade mathematics classrooms. The points we make go well beyond mathematics, however—and certainly well beyond eighth grade. Mathematics teachers might find the book especially interesting, but our intention became to write a book that would be of interest to teachers in all subjects at all levels.

Teachers are not the only audience for this book. We have written it for school administrators, policymakers, politicians,

and parents. Although teachers hold the key, they teach in a system that currently works against improvement. Unless other important players get involved, our country cannot implement a program that allows teachers to improve teaching. This would be unfortunate, not because it would miss *an* opportunity but because it would miss the *only* opportunity. The system must support teachers to improve teaching, because teachers are the key to closing the gap.

. . .

This book, and the study from which it grew, could not have been completed without the help of many people.

The TIMSS video study was funded by a contract from the National Center for Education Statistics (NCES), U.S. Department of Education, to WESTAT, Inc. The views expressed in this book, however, should in no way be construed to be those of NCES or of the U.S. Department of Education.

We are grateful to Emerson Elliot, past commissioner of NCES, and to Pascal Forgione, the current commissioner, whose support and enthusiasm went well beyond the financial. Lois Peak, the NCES program officer who oversaw the study, worked tirelessly to help us through the intricacies of a government project. Without her unwavering belief in the importance of this work, the study would never have been done. And we thank Nancy Caldwell of WESTAT for her constant and dependable help throughout the contract.

The TIMSS video study could not have been done without the help of our international collaborators. Juergen Baumert and Rainer Lehmann (in Germany) and Toshio Sawada (National Institute of Educational Research, Tokyo) managed the data-

collection process and helped us to understand teaching in their countries.

Clea Fernandez, of Teachers College/Columbia University, played a major role in the early planning and conceptualization of the project; Scott Rankin trained the videographers for the study; Takako Kawanaka, Steffen Knoll, and Ana Serrano led our coding-development efforts; Patrick Gonzales managed the transcription and translation process and contributed to our analyses of classroom discourse; Eric Derghezarian, Fumiko Ichioka, and Nicole Kersting worked endless hours in the analysis of videotapes; Gundula Huber and Alyne Delaney handled the digitizing of the tapes; and Ken Mendoza wrote the software that enabled us to manage the huge quantity of video collected in the study. We want to recognize these individuals for the important role they played in the project.

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We also want to thank Susan Arellano, formerly of the Free Press, who believed in the book and sold the idea to the Free Press; and Philip Rappaport, our editor at the Free Press, whose clear vision and timely input helped us write a book that could speak to a real audience.

Finally, we thank our families, whose support and tolerance made this book possible: Karen Stigler, Sam Stigler, Thomas Stigler, and Charlie Stigler; and Diana Wearne.

We welcome your comments on *The Teaching Gap*. Please visit our Web site at www.lessonlab.com/teaching-gap.

CHAPTER 1

The Teaching Gap

CONDITIONS FOR IMPROVING education in the United States are more favorable today than they have been in a generation. Both politicians and the public recognize that education needs to be improved. Bad news from international comparisons of student achievement is no longer seen as esoteric by the American public; these days it is on the front page and a linchpin of many politicians' stump speeches. In our increasingly global economy, citizens see direct evidence that America's future will depend on the education of its workforce, and they are determined to compete. Education has become a high priority among the electorate.

But the real reason for optimism is that all this attention to education is not just rhetoric. We are witnessing a tidal wave of educational reform that appears to gain momentum with each passing year. Virtually every state in the nation is working to develop high standards for what students should learn in school, along with means for assessing students' progress. In a field where fads have ruled, we are seeing something new: a growing commitment to the idea that clear and shared goals for student learning must provide a foundation on which to improve education and achievement. Without clear goals,

we cannot succeed, for we cannot know in which direction to move.

Yet it is equally important to recognize that standards and assessments, though necessary, are not enough. What must be done now is to find ways of providing students with the learning opportunities they need to reach the new standards. Making higher standards a reality for students will require more than just the status quo inside our nation's classrooms; curriculum, assessments, and—above all—teaching must improve dramatically. In our view, teaching is the next frontier in the continuing struggle to improve schools. Standards set the course, and assessments provide the benchmarks, but it is teaching that must be improved to push us along the path to success.

Our contention that standards alone are not enough is shared by many politicians and school reformers, and they stand ready to help. President Clinton has successfully pushed through legislation that will pour millions of dollars into reducing class size in elementary schools nationwide.[1] Many states are actively considering making vouchers and school choice a central part of their educational systems. And many school districts are embarking on additional initiatives, such as creating charter schools, outfitting schools with new technologies, and sanctioning new forms of school management.

We believe that these highly visible efforts, though well intentioned, miss the mark, because they leave out the one ingredient most likely to make a difference in students' learning: the quality of teaching. Reducing the class size from thirty to twenty certainly will make teachers happier. But if teachers continue to use the same methods they used with larger classes, learning opportunities for students will change little. Similarly, implementing a voucher system might increase

competition among schools and spur their desire to improve. But desire alone does not provide teachers with the knowledge they need to implement more effective methods. Class size reductions, vouchers, and most other popular efforts to improve schools will end in disappointment if they do not fundamentally improve what happens inside classrooms.[2]

We are not the only ones to decry this lack of attention to the improvement of teaching. Jerome Bruner, an elder statesman in educational psychology, made the same point in his 1996 book, *The Culture of Education:*

> It is somewhat surprising and discouraging how little attention has been paid to the intimate nature of teaching and school learning in the debates on education that have raged over the past decade. These debates have been so focused on performance and standards that they have mostly overlooked the means by which teachers and pupils alike go about their business in real-life classrooms—how teachers teach and how pupils learn.[3]

Our goal in writing this book is to convince our readers that improving the quality of teaching must be front and center in efforts to improve students' learning. Teaching is the one process in the educational system that is designed specifically to facilitate students' learning. Of course, there are many other factors that influence learning in a significant way, such as students' home and social life, and the resources of the school and community.[4] We do not want to minimize the importance of these for the well-being of children. But much of what our society expects children to learn, they learn at school, and teaching is the activity most clearly responsible for learning.

Robert Slavin, long a leading educational researcher, made a similar observation in a recent article:

> The problem, I would argue, is that reforms so often debated in the media, in the White House, in Congress, and in statehouses across the country do not touch on the changes needed to fundamentally reform America's schools. . . . These reforms ignore a basic truth. Student achievement cannot change unless America's teachers use markedly more effective instructional methods.[5]

What makes this argument compelling is that not only is teaching essential, it is a process we can do something about. Overemphasizing the importance of nonschool factors that often are, frustratingly, beyond the reach of public policy can become an excuse for not trying to improve. Teaching lies within the control of teachers. It is something we can study and improve.

The Learning Gap and the Need to Improve

Good questions to ask at this point are "Why is it so important to improve teaching?" and "How do we know that improvement is needed? Maybe we are doing fine." Surprising as it may seem, there is considerable controversy about the answers to these questions. Influential educators and writers disagree.[6] One answer is simply that there is always room for improvement; no matter how well our students are doing now, it would be foolish not to try to improve.

The truth, as we see it, however, is that the situation in the United States demands improvement, not just because improvement is possible but because it is needed. Our students *are* being shortchanged. They could be learning much more and much more deeply than they are learning now. In the most recent National Assessment of Educational Progress, a periodic thermometer of students' learning, only 38 percent of America's eighth-graders could figure out a 15 percent tip on the cost of a typical meal, even when given five choices from which they could select the correct answer.[7] Is this good enough?

Beyond the surveys of our own country's students, there are a number of sobering international reports. Several years ago, one of us coauthored a book called *The Learning Gap.*[8] That book presented a study of schooling and achievement in Japan, Taiwan, China, and the United States. The findings were cause for concern: As early as fifth grade, U.S. students lagged far behind their counterparts in the other countries. On a test of mathematics achievement, for example, the highest-scoring classroom in the U.S. sample did not perform as well as the lowest-scoring classroom in the Japanese sample.

Interest in international studies has grown since publication of *The Learning Gap,* heightened recently by release of the results of the Third International Mathematics and Science Study (TIMSS). As the name implies, this was the third in a series of international studies. The first was conducted in the 1960s and the second in the early 1980s. In both of these studies, U.S. students performed quite poorly compared with their peers in most Asian and many European countries.[9] But neither of these two earlier studies came close to matching the size and quality of the TIMSS, by far the most comprehensive and methodologically sophisticated cross-national comparison of achievement ever completed. TIMSS investigated mathematics and science achievement among fourth-, eighth-, and twelfth-grade students in forty-one nations.[10]

The results from TIMSS have garnered a great deal of media interest and have caught the attention of politicians, policymakers, and the general public. The results are dramatic, and they do not paint a flattering picture of American education. For example, in eighth-grade mathematics, twenty of the forty-one nations scored significantly higher, on average, than the United States, while only seven nations scored significantly lower than the United States. The seven nations scoring lower than the United States were Lithuania, Cyprus, Portugal, Iran, Kuwait, Colombia, and South Africa. Nations scoring significantly higher than the United States included Singapore, Korea, Japan, Canada, France, Australia, Hungary, and Ireland.

Of course, the results of large international studies are always open to question. So much differs across cultures and educational systems, it is hard to know where to find the most meaningful comparisons. Are the samples comparable? Do we even have the same goals for education across cultures? Although the answers to these questions are important for interpreting the differences, the gap in achievement between U.S. students and those in other countries is simply too wide to be dismissed on methodological grounds. U.S. education is in need of improvement.

Beyond the Learning Gap

Americans increasingly are aware of this learning gap and are seeking ways to address it. The international comparisons grab the front-page headlines, and officials try to infer recommendations from how one country performs compared with the performance of another. Policymakers carefully study, state by state, scores on the most recent National Assessment

of Educational Progress, as if one could divine a strategy, from the scores, for improving performance. Scores of all local schools are printed in the newspaper, and school boards and parents discuss why students in some schools score much lower than others.

As important as it is to know how well students are learning, examinations of achievement scores alone can never reveal how the scores might be improved. We also need information on the classroom processes—on teaching—that are contributing to the scores. Unfortunately, many policymakers have ignored this fact, making decisions about the future of education without even the most rudimentary information about what is happening in classrooms. In 1995, faced with low reading and mathematics performance on the National Assessment of Educational Progress, California's superintendent of public instruction formed two task forces, one for mathematics and one for reading, to study the situation and propose solutions. California, after all, was highly respected for its Curriculum Frameworks that guide reading and mathematics instruction in the state.[11] The Frameworks provided a comprehensive outline for what students should learn and guidelines for appropriate instructional methods. If the Frameworks were so good, why was achievement so low?

In meetings of California's mathematics task force, the discussion often turned to the Frameworks. Were the teaching methods or curricular emphases recommended in the Mathematics Framework perhaps to blame for students' low achievement? A debate ensued among members of the task force, a debate that has been reflected more broadly in public debate around the country between proponents of "reform" teaching and those in favor of more "traditional" teaching methods.[12] Some believed that the Frameworks were not working and

should be changed; others believed that the state should stay the course. But often lost in the discussion was a key fact: the state of California had collected no data on the extent to which the Frameworks had been *implemented* in the state's classrooms. This did not stop the state, however, from undertaking a revision of its Mathematics Framework. But on what basis could the Framework be revised? Without knowing what teachers were doing, how could the effectiveness of the Framework be determined?

We do not mean to single out California; no state that we know of regularly collects and uses data directly related to instructional processes in the classroom. Policymakers adopt a program, then wait to see if student achievement scores will rise. If scores do not go up—and this is most often what happens, especially in the short run—they begin hearing complaints that the policy isn't working. Momentum builds, experts meet, and soon there is a new recommendation, then a change of course, often in the opposite direction. Significantly, this whole process goes on without ever collecting data on whether or not the original program was even implemented in classrooms—or, if implemented, how effective it was in promoting student learning. If we wish to make wise decisions, we need to know what is going on in typical classrooms.

Fortunately, the same TIMSS that generated a new wave of concern about students' achievement also collected a wealth of information about educational factors that might help us understand the different levels of performance in different countries. TIMSS researchers analyzed textbooks; asked administrators, teachers, and students about their beliefs and practices; and videotaped teachers teaching typical lessons. The TIMSS video study of teaching, which forms the basis for this book, is especially significant because it provides a penetrating and unparalleled look into classrooms in three different countries. For the first time, we had a full video record of a representative sample of U.S. classrooms. More than that, we had the same kind of information from Germany and Japan. We could now compare more than achievement scores. We could examine similarities and differences in the instructional methods that lay behind these scores.

A Unique Opportunity

The data collected in the TIMSS video study allow us to answer questions that we could not answer previously yet are crucial for the formation of education policy in the years to come. What are the instructional methods that most teachers currently use? Are the highly publicized reform recommendations being implemented in the classrooms of the United States? Are there alternative ways of teaching in other cultures, or is mathematics teaching pretty much the same everywhere? As was pointed out earlier, a major obstacle in our efforts to improve education is the dearth of information about what is happening in our nation's classrooms. Video provides us with a unique way of gathering the information we need to examine our current practices and then improve them.

Video data, such as that collected in TIMSS, also help us discover new ideas about teaching. If alternative ways of teaching exist, video will capture them, even when they lie completely outside our society's current theories of teaching and learning. And because the new ideas are illustrated through actual classroom teaching, they can have immediate practical significance for teachers. Video information can shake up the way we think and let us take a fresh look at classrooms.

What We Have Learned from the Video Study

As we look back over what we have learned from the TIMSS video study, several things stand out. We foreshadow these things here because they form the basis for the book you are reading.

Teaching, Not Teachers, Is the Critical Factor

Americans focus on the competence of teachers. They decry the quality of applicants for teaching positions and criticize the talent of the current teaching corps. But we come away with a different conclusion: Although variability in competence is certainly visible in the videos we collected, such differences are dwarfed by the differences in *teaching methods* that we see across cultures. (In Chapters 2, 3, and 4 we present our analyses of teaching and describe what teaching looks like in each country.)

We have watched many examples of good teachers employing limited methods that, no matter how competently they are executed, could not lead to high levels of student achievement. Although there are teachers using extraordinary methods in all cultures, the extraordinary is not what defines most students' classroom experiences. Students' day-to-day experiences are mainly determined by the methods most commonly used by teachers within a culture. Cross-cultural differences in these commonly used methods are what we have termed the "teaching gap."

What we can see clearly is that American mathematics teaching is extremely limited, focused for the most part on a very narrow band of procedural skills. Whether students are in rows working individually or sitting in groups, whether they

have access to the latest technology or are working only with paper and pencil, they spend most of their time acquiring isolated skills through repeated practice. Japanese teaching is distinguished not so much by the competence of the teachers as by the images it provides of what it can look like to teach mathematics in a deeper way, teaching for conceptual understanding. Students in Japanese classrooms spend as much time solving challenging problems and discussing mathematical concepts as they do practicing skills.

Teaching Is a Cultural Activity

To put it simply, we were amazed at how much teaching varied across cultures and how little it varied within cultures. When we started, we believed there would be great variability in teaching methods within the United States. Political battles between advocates of, among other teaching techniques, phonics and whole language, and basic skills and conceptual understanding, would lead most Americans to assume that there are many different paths that teachers can follow. But these differences paled when we looked across countries from a cross-cultural, comparative perspective. Although we saw variation in the U.S. videos we collected, comparing them with videos from Germany and Japan allowed us to see something we could not see before: a distinctly American way of teaching, which differs markedly from the German way and from the Japanese way.

Teaching is a cultural activity. We learn how to teach indirectly, through years of participation in classroom life, and we are largely unaware of some of the most widespread attributes of teaching in our own culture. (In Chapters 5 and 6 we pull together what we have learned about teaching and argue that if we are going to improve teaching, we must appreciate its

cultural character.) The fact that teaching is a cultural activity explains why teaching has been so resistant to change. But recognizing the cultural nature of teaching gives us new insights into what we need to do if we wish to improve it.

A Gap in Methods for Improving Teaching

Finally, we have learned a great deal from the video study about the results of efforts to improve teaching in the United States. Earlier in this chapter we pointed to the dearth of information about the effects that educational policies have in the classroom. The videos provide us with this kind of information, and it is quite striking. Although most U.S. teachers report trying to improve their teaching with current reform recommendations in mind, the videos show little evidence that change is occurring. Furthermore, when teachers do change their practice, it is often in only superficial ways.

This will not surprise those who have worked in the field of teacher professional development. The problem of how to improve teaching on a wide scale is one that has been seriously underestimated by policymakers, reformers, and the public in this country. The American approach has been to write and distribute reform documents and ask teachers to implement the recommendations contained in such documents. Those who have worked on this problem understand that this approach simply does not work. The teaching profession does not have enough knowledge about what constitutes effective teaching, and teachers don't have a means of successfully sharing such knowledge with one another.

To really improve teaching we must invest far more than we do now in generating and sharing knowledge about teaching. This is another sort of teaching gap. Compared with other countries, the United States clearly lacks a system for developing

professional knowledge and for giving teachers the opportunity to learn about teaching. American teachers, compared with those in Japan, for example, have no means of contributing to the gradual improvement of teaching methods or of improving their own skills. American teachers are left alone, an action sometimes justified on grounds of freedom, independence, and professionalism. This is not good enough if we want excellent schools in the next century. (In Chapters 7, 8, and 9 we discuss the problem of how to improve teaching, and offer a proposal to make improving teaching the focus of our efforts to close the achievement gap.)

We opened this chapter by describing the opportunities that exist at present for improving education. In this positive environment, the challenge that awaits our nation is to find a way to improve classroom teaching so that our educational goals can be realized.

CHAPTER 2

Methods for Studying Teaching in Germany, Japan, and the United States

THE STORY OF the TIMSS video study begins in 1993, when, for the first time in history, plans were made to videotape an international sample of eighth-grade mathematics teachers. Each teacher would be videotaped teaching one lesson in his or her own classroom.

Imagine a videographer, Ron Kelly, traveling around the United States for seven months, loaded with equipment, taping in a different school each day. At the same time, Andrea Lindenthal was driving around her native Germany, filming a different mathematics lesson each day, and Tadayuki Miyashiro was doing the same thing in Japan. They all were collecting data for the Third International Mathematics and Science Study.

Birth of the TIMSS Video Study

Planning for TIMSS was largely funded by the U.S. government, through the National Center for Education Statistics and the National Science Foundation. Long before any data were collected, teams of researchers were meeting and designing the tests and questionnaires that would be administered in forty-one countries.[1] Most officials anticipated that American students would not fare well in the cross-national comparisons. The previous international comparisons had provided ample warning. But many of those involved in planning this study now understood that just worrying about low achievement scores would not help improve the scores. This time, officials wanted to be ready to discuss the reasons for low levels of student achievement and to suggest ways to improve achievement. They consulted widely with experts in mathematics and science education, looking for new ways of studying the processes that lead to student learning.

From early on, there was a great deal of interest in collecting information on classroom instruction. Yet there was little agreement on how to do this. Previous large-scale international work had relied on questionnaires to collect information, a relatively inexpensive procedure. Perhaps teachers could be sent a questionnaire and asked to describe the methods they used. The problem was that it would be hard to interpret their responses. It is difficult to know how accurately teachers describe their methods and what they mean by the words they use. For example, if a teacher says she does "problem solving" (currently a popular phrase) with her students, what, exactly, does she do? Different teachers use the same words to mean different things.

Videotaping teachers teaching in their own classrooms

would solve this problem, but it was a radical idea. Video has been around for some time, and researchers have used it to study teaching. But no one had used video to collect a national sample of anything, certainly not teaching. The logistical problems alone were daunting. But the opportunity to peer into the classrooms of various countries was too exciting to pass up.

So was born the video study. Because the goal was to find out more about some of the things that might account for students' performance, the planners wanted to videotape teaching in a variety of countries. But which ones? Videotaping in all forty-one countries was impossible, for both logistical and financial reasons. Three countries were chosen: the United States, Japan, and Germany. Japan was an obvious choice because it has always scored near the top in international comparisons of mathematics achievement. Germany, though it had not participated previously in the large international studies, was also considered an important comparison country, because Germany, like Japan, is a major economic competitor of the United States. The stage was set.

Goals of the TIMSS Video Study

Although the challenges of using video on a large scale are considerable, the major goals of the TIMSS video study were simple and straightforward:

1. To learn how eighth-grade mathematics is taught in the United States.
2. To learn how eighth-grade mathematics is taught in two comparison countries, Germany and Japan.

3. To learn something about the way American teachers view reform and whether they are implementing teaching reforms in their classrooms.

These goals point us toward the first step we must take to improve education in the United States. They focus attention on classroom teaching and on collecting basic information on the instructional methods we currently are using. They allow us to answer fundamental questions that until now we could only guess at: "How do most American teachers teach?" and "How does this compare with how their peers in other countries teach?"

Research Methods: The Nuts and Bolts

We started this chapter with three videographers, one in each country, traveling from school to school. Let us go back to describe in more detail how the video study was conducted.[2]

Once inside the classroom, the videographers collected two main types of data: a videotape of the lesson and a questionnaire response from the teacher. They also collected supplementary materials, such as copies of textbook pages or worksheets, that were helpful for understanding the lesson. Each classroom was videotaped for one complete lesson on a date convenient for the teacher.

Because there are a number of ways in which the integrity of a study like this could be undermined, it is important to understand a few key features of the study. Having confidence in the findings depends on knowing how we dealt with the following issues.

Which Classrooms Should Be Videotaped?

The sample of the study is crucial: If we were to produce a national-level portrait of eighth-grade mathematics instruction, we needed to be sure that the sample of teachers was representative of eighth-grade mathematics teachers. Fortunately, the TIMSS sampling plan was highly sophisticated, and the video sample was constructed to be a random subsample of the full TIMSS sample.

Selecting classroom lessons was not easy. Schools were selected first, then teachers, and then classes. Often we were asked by the school to substitute one teacher for another, or by the teacher to videotape a different class period than the one that had been sampled. We allowed no substitutions of either sort, because to do so would have introduced bias into the study.

The final sample was a "national probability sample." This technical term means that every eighth-grade math teacher in the country and each of the teacher's classes had an equal chance of being selected for the study. This was true in all three of the countries studied. The final video study sample included 231 eighth-grade mathematics classrooms: 100 in Germany, 50 in Japan, and 81 in the United States.[3] Although the number of lessons was not large, because they were sampled randomly we could be sure that they approximated, in their totality, the mathematics instruction to which students in the three countries were exposed. In short, we had a sample that met the highest standards in statistical methodology.

Will the Camera Change What the Teacher Does?

Many people wonder whether the videotapes show what teachers normally do when the camera is not present. Teachers knew, after all, that the videographer was coming. Surely they

would try to prepare in some way. They might even go so far as to design a special lesson just for the videotaping. Even if this did not happen, the presence of the camera might affect a teacher's behavior in subtle, unconscious ways. This was a serious concern, and we did not take it lightly.

We explained the goal of the study to all the teachers and asked them to teach the same lesson they would have taught if the camera had not been there. Most teachers do not want to bias a research study, but some might inadvertently do so to please or impress the researchers. We told them we wanted to see a typical lesson, the one they had originally scheduled for that day.

To check on typicality, we asked teachers to describe in the questionnaire what they did in the same class the previous day and what they were planning to do the next day. This helped us to determine whether the teacher had taught a special, stand-alone lesson for the camera or whether, as we hoped, the taped lesson fit within an ongoing sequence. Teachers' responses indicate that few lessons were stand-alone, and we believe most were quite typical.

Finally, we used common sense in deciding the kinds of indicators that might be susceptible to bias and took this into account when interpreting the results. It seems likely, for example, that students were on their best behavior in front of the camera, so we believe the videotapes do not show the normal frequency with which teachers must discipline students. On the other hand, it seems unlikely that teachers asked completely different kinds of questions while being videotaped than they did when the camera was not present. Some behaviors, such as the routines of classroom discourse, are so highly socialized that they are almost automatic and are difficult to change.

Turning Videos into Information

After we collected the videos, the difficult task of analysis began. Meaning is not contained in the videos; it must be constructed by the researcher through a difficult and painstaking process. We began this process in May 1994 with a set of nine trial tapes from each country. A team of six code developers—two from Germany, two from Japan, and two from the United States—and several mathematics educators spent the summer at UCLA watching and discussing the contents of the tapes. Our goal was to understand how teachers construct and implement lessons in each country, and to develop a common language for describing the lessons.

The process was a straightforward one: we would watch a tape (subtitled in English), discuss it, and then watch another. Anyone could stop the tape at any time. The discussion was so vigorous that it often would take a day or more to get through a single lesson. There were disagreements in the group about the contents of the tapes, and especially about how to describe them. But gradually, as we worked our way through the twenty-seven tapes, we began to develop a common view of the nature of teaching in the three countries. More than that, we began to develop a coding system to compare teaching across the three countries.

Many people who are unfamiliar with behavioral research do not understand how it is possible to code video objectively. They assume that there is only one thing to do with video: watch it. But there is a great deal more one can do. It is possible to move beyond individual impressions and identify features of the events portrayed in a video objectively, so that anyone who watches can agree. These objective judgments can be used to quantify the events on the video so that one can know how frequently different categories of activities occur.

The process begins with a discovery that is turned into a hypothesis. For example, we might notice that German teachers develop concepts more fully than do U.S. teachers, or that Japanese teachers ask more open-ended questions than do German and U.S. teachers. We then propose this "discovery" as a hypothesis. The next step is to write a definition that will communicate to other coders what "counts as" developing a concept or as asking an open-ended question. Anyone who has engaged in this process knows that it is not easy to write such a definition. But it can be done. For example, how do you even know something is a question? Would something like "Do you think you could open the door?" count as a question just because it ends with a question mark? Clearly it should not, because in American culture such a statement is a request, not a question.

The test of how successful we were in developing objective codes was the degree to which independent coders made the same judgment when viewing the same segment of video. The convention in behavioral research is to accept as reliable only those codes on which independent coders make the same decision at least 80 percent of the time. All the codes we discuss in this book met this criterion.

The process of turning videos into information yielded two kinds of products: impressions or images of teaching in each country, and quantified results that indicate how often specific features of teaching occur in each country. The images are vivid and powerful. One picture, it is said, is worth a thousand words; one video may be worth millions. On the other hand, the images produced by video can be too powerful, because they can focus attention on one striking example, even when the example is not typical. Coded data help correct these errors and may themselves lead to interesting discoveries. So

both kinds of information are crucial for learning about teaching across cultures.

We now turn to the results of the study, and we begin with the first kind of information—images of teaching in Germany, Japan, and the United States.

CHAPTER 3

Images of Teaching

IN THE FALL of 1994, after several months of watching tapes, the project staff met to present some preliminary impressions and interpretations. We invited distinguished researchers and educators from Germany, Japan, and the United States to attend, and we listened intently to what they had to say. We were ready for a fresh perspective. It came late on the last day of the meeting. One of the participants, a professor of mathematics education, had been relatively silent throughout the day. We asked him if he had any observations he would like to share.

"Actually," he began, "I believe I can summarize the main differences among the teaching styles of the three countries." Everyone perked up at this, and here is what he had to say: "In Japanese lessons, there is the mathematics on one hand, and the students on the other. The students engage with the mathematics, and the teacher mediates the relationship between the two. In Germany, there is the mathematics as well, but the teacher owns the mathematics and parcels it out to students as he sees fit, giving facts and explanations at just the right time. In U.S. lessons, there are the students and there is the teacher.

I have trouble finding the mathematics; I just see interactions between students and teachers."

Many of those present were somewhat dumbfounded by this description. How grossly oversimplified it seemed! It also was harshly critical of the American style of teaching and was disturbing to hear. But the image stayed with us, and as we watched the tapes over and over we began to understand that our colleague had captured an important aspect of what we saw in the tapes from all three countries. Although perhaps oversimplified, our colleague's description helped us to see features that might otherwise have been hidden within the noise and complexity of classroom life. Simplified descriptions provide an important starting point for understanding complex activities, provided we are open to revising, tempering, or even discarding them when they outlive their usefulness.

We begin our journey into the TIMSS videos with our own simplified descriptions of teaching in each country. We then present a typical lesson from each country. Because we realize that the typical lesson could never describe every teacher, we conclude the chapter by reporting some ways in which lessons might vary from the typical. Our goal is to help create accurate and rich visual images of teaching in each country.

Preliminary Descriptions of Teaching

Our impression is that teachers in Germany are in charge of the mathematics and that the mathematics is quite advanced, at least procedurally. In many lessons, teachers lead students through a development of procedures for solving general classes of problems. There is concern for technique, where technique includes both the rationale that underlies the procedure and the precision with which the procedure is executed. A good motto for German teaching would be "developing advanced procedures."

In Japan, teachers appear to take a less active role, allowing their students to invent their own procedures for solving problems. And these problems are quite demanding, both procedurally and conceptually. Teachers, however, carefully design and orchestrate lessons so that students are likely to use procedures that have been developed recently in class. An appropriate motto for Japanese teaching would be "structured problem solving."

In the United States, content is not totally absent, as was portrayed by our colleague, but the level *is* less advanced and requires much less mathematical reasoning than in the other two countries. Teachers present definitions of terms and demonstrate procedures for solving specific problems. Students are then asked to memorize the definitions and practice the procedures. In the United States, the motto is "learning terms and practicing procedures."

What do the mottoes "developing advanced procedures," "structured problem solving," and "learning terms and practicing procedures" look like in actual classrooms? In the following sections we describe three actual lessons selected to typify the lessons sampled from each country.

Portraits of Eighth-Grade Mathematics Lessons

The Classrooms

Even though the videotaped classrooms are located thousands of miles apart and in different cultures, they look much the same.

Rows of students' desks, posters on the walls, the teacher's desk and a chalkboard in front—all provide few clues about the country from which the video comes. Students filing into class, individually and in pairs, jostling and joking and laughing, create a remarkably similar atmosphere in each country.

But there are differences. Although German and American students often dress alike—casually, in denim pants and T-shirts or sweatshirts—Japanese students usually dress in school uniforms: special jackets for boys, blouses and skirts for girls. There are fewer students in the German and U.S. classrooms than in the Japanese classrooms. The national average for eighth-grade class size in each country is twenty-five in Germany and the United States, and thirty-seven in Japan.

The typical lessons we describe in this chapter are from classrooms found in somewhat different school situations. In Germany, eighth-graders attend different schools based on their academic achievements and aspirations. The classroom we describe is located in a *Realschule,* the middle track of the three-tiered German school system. Most students attending a *Realschule* will not go on to university, but many expect to enroll in a technical or vocational college. The classroom in Japan is located in a small-city public school with no special distinctions. Japan has no system for tracking students in elementary and middle school. All eighth-graders take the same mathematics course, so the classroom we describe contains students of mixed achievement levels. The classroom in the United States is located in a large public school in the suburbs of a sprawling metropolitan area. The school offers only one mathematics course in eighth grade, so, as in Japan, the classroom contains students of mixed achievement levels.

What about the lessons themselves? Again, there are some interesting similarities and some striking differences. The lessons we describe are about the same length, forty-five to fifty minutes. Some of the time in each lesson is devoted to teacher presentation, some to class discussion, and some to student work. But if the mottoes suggested earlier mean anything, there must be some significant differences in what happens during these activities and how they are arranged. To really understand the differences in classroom teaching, one needs to look carefully at the details of typical lessons, because this is where the teaching gap is revealed. The teaching gap is not an abstract idea concocted by ivory tower researchers; the teaching gap is a set of real differences in the teaching methods used every day in typical classrooms. These differences that accumulate over time and across the country are bound to affect what and how students learn.

Studying the details of lesson design is important but not always easy. The following table might be helpful because it gives an overview of the three lessons we describe and it includes our observations about what features of the lessons typify teaching in each country. To appreciate the sometimes subtle but profound differences in teaching, however, one must study the lessons themselves.

A German Lesson: Developing Advanced Procedures

When the bell rings, Mr. Eisner, the teacher, greets the students: "Good morning."[1] The students respond, "Good morning," and Mr. Eisner says, "Okay, let's start right away, as usual, with our homework." As students pull out their worksheets, Mr. Eisner checks attendance by glancing around the room and recording the students who are absent.

TIME	GERMAN LESSON	JAPANESE LESSON	U.S. LESSON
1 min	Teacher checks homework by calling on students for answers. Students work more difficult homework problems on board. Teacher corrects terminology. *Note: Typical for teacher to be careful about notation and language. Unusual to spend this much time checking homework.*	Teacher reviews yesterday's lesson and assigns a problem that was not finished.	Teacher asks students short-answer review questions. *Note: Typical to begin with "warm-up" activity.*
		Students present solution methods they have found, and teacher summarizes.	Teacher checks homework by calling on students for answers. *Note: A common way to check homework.*
10 min		Teacher presents task for the day and asks students to work on it independently (task is to invent problem for classmates to solve). *Note: Typical to present task for the day and allow students to solve it in their own way. Often, task can be solved using method students have learned recently.*	Teacher distributes worksheet with similar problems. Students work independently.
			Teacher monitors students' work, notices some confusion on particular problems, and demonstrates how to solve these. *Note: Typical for teacher to intervene at first sign of confusion or struggle.*
20 min	Teacher presents problem for the day—a theorem for students to prove—and leads them through the proof. Teacher emphasizes the procedures that can be used to prove theorems like this. *Note: Proving a theorem is unusual, but the teacher leading the students through a discussion of advanced procedures is common. Often, a student will be at the board for part of the discussion.*	Teacher suggests they continue their work in small groups. Leaders of groups share problems with teacher, who writes them on board. Students copy problems and begin working on them. *Note: Unusual for students to work this long without a class discussion. Typical for students to struggle with task before teacher intervenes.*	Teacher reviews another worksheet and demonstrates a method for solving the most challenging problem.
30 min			
	Class reviews the theorem by students reading aloud from a handout.		Teacher conducts a quick oral review of problems like those worked earlier.
40 min			
	Teacher assigns homework. *Note: Typical to allow no class time for working on homework.*	Teacher highlights a good method for solving these problems. *Note: No homework is typical.*	Teacher asks students to finish worksheets. *Note: Unusual to not assign homework.*

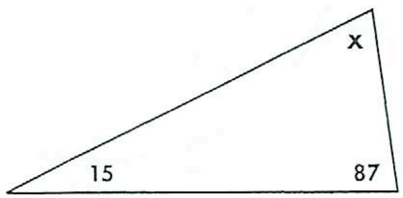
AUTHORS' NOTES

Opening
Common for lessons in all countries to begin with review. But Germany and the United States begin with relatively long segments of checking homework; Japan begins with a quick review of yesterday's lesson.

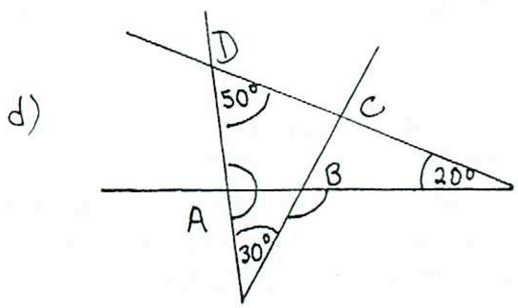
Heart of the Lesson
Germany: Teacher leading students through the development of advanced techniques for solving challenging problems, with students responding to frequent questions.
Japan: Students working on challenging problem and then sharing their results.
United States: Teacher engages in quick-paced question/answer with students, demonstrates methods, and asks students to work many similar problems.

Closing
The lessons conclude in different ways: Germany and the United States often with assigning homework; Japan with the teacher summarizing the main point(s) of the lesson.

Checking Homework. Mr. Eisner then calls on students, one at a time, to give the answer to the next problem on the worksheet. After each response, he looks up to see if anyone disagrees. If so, he asks for other responses and endorses one of these as correct, or explains why the error might have been made and gives the correct answer. The first eleven problems are quite straightforward. They require finding the measure of the third angle in a triangle, given the first two, as in the drawing below. Students must simply add the measures of the two angles and subtract from 180 to find the measure of the missing angle.



But the next problems are more challenging. One presents the drawing below and asks students to find the angles labeled with capital letters. Students apparently had more trouble with these at home, and there is disagreement about the answers.



Mr. Eisner asks a volunteer to come to the board to explain the solution. As the student works, Mr. Eisner corrects errors,

elaborates on the descriptions provided by the students, and makes sure students are using correct mathematical language. The discussion regarding the problem shown above begins as follows.

Mr. Eisner: Which one could we figure out with the help of the indicated measures? Birgit? It's best if you come to the front, because it's always a little difficult describing it having so many angles.

Birgit: This is one hundred ten degrees (*pointing to the angle opposite A*).

Mr. Eisner: You claim one hundred ten degrees. Can you add an explanation to that?

Birgit: Yes. Because it's in the triangle of fifty degrees and twenty degrees.

Mr. Eisner: Yes, I'll show it again. You are talking now about this triangle (*pointing to the large triangle*). That's twenty degrees and that's fifty degrees, and therefore this third angle has to be, inevitably?

Birgit: One hundred ten degrees.

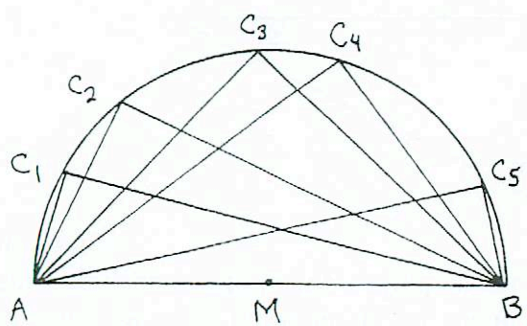
The rest of this problem, and the remaining homework problems (twenty-two in all), are checked in a similar way. It is now fourteen minutes into the lesson.

Presenting the Topic for the Day. Mr. Eisner presents the new problem that will define today's lesson.

Mr. Eisner: Questions, disagreements concerning homework? Good, then we will construct a little. We need our

> tools for that. Okay, please draw first an arbitrary distance AB. I wouldn't make it too small, but there has to be space above the distance so we can put a semicircle there. . . . Okay, construct now for the distance AB the perpendicular line at the midpoint. . . . Actually, I don't care so much about the perpendicular line but only about the midpoint. . . . Around M [the midpoint] we will now draw a semicircle.

After the construction, which takes about five minutes, Mr. Eisner asks the students to "mark on the edge of the circle five arbitrary points and call them C_1, C_2, . . . C_5" and then "connect with point A and point B so five triangles emerge." A sample drawing now looks like this:

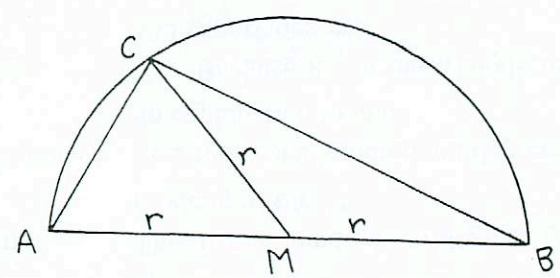


Mr. Eisner asks the students to measure, with their protractors, all five angles at the five C's. After a few minutes, the students begin reporting that all five angles are the same size; they all measure 90 degrees. Mr. Eisner pretends to be startled by this result and tries to get students to share his surprise. He then notes that an ancient Greek mathematician (Thales) found that all angles drawn inside a semicircle like this will

measure 90 degrees. Now the stage is set, and Mr. Eisner presents the real challenge: "We did check it, but we also want to prove it, of course. . . . Prove that it really has to be that way and can't be any other way."

Here we see the advanced nature of the mathematics in German classrooms: proving the Law of Thales is a challenging task for eighth-graders.

Working Through the Proof. As is common in Germany following the presentation of a challenging problem, Mr. Eisner neither leaves the students alone to complete the task by themselves nor demonstrates a quick method that students are supposed to imitate. Using the drawing below, he leads the class through a careful development of the proof.



Two triangles, AMC and BMC, have radii for two of their sides, so they are isosceles triangles. This means that each triangle has a pair of equal angles. By locating these angles in the drawing, it is possible to see that angle C comprises one angle equal to angle A and one angle equal to angle B. The sum of the three angles (A, B, and C) is 180 degrees, because they make up the large triangle ABC. Because angle C must be the same as angle A plus angle B, the measure of angle C

must be exactly half of the 180 degrees, or 90 degrees. Mr. Eisner leads students through this proof step by step, asking students to respond to short-answer questions along the way.

Reviewing the Topic. It is now thirty-five minutes into the lesson, and Mr. Eisner hands out two pages summarizing the Law of Thales and its history. He selects students to read aloud small sections of the handout and asks if there are questions.

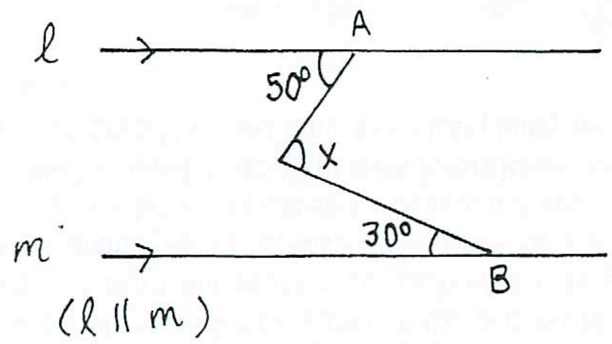
Assigning Homework. The lesson concludes with the assignment of homework. The problems require finding the measure of missing angles. Some involve the Law of Thales, some a review of previous work. Mr. Eisner asks if there are any questions about the problems, then says, "Okay. You can start with that until the bell." One minute later, forty-five minutes after the lesson began (about average for a German lesson), the bell rings.

A Japanese Lesson: Structured Problem Solving

From an American point of view, the Japanese lesson begins in a rather striking way. At the signal from the student monitor, all the students stand and bow, in unison, to the teacher. The teacher bows in return, and the lesson is officially under way.

Reviewing Yesterday's Lesson. After the customary exchange of bows, the students sit down and engage in a bit of joking with Mr. Yoshida, the teacher, about the video camera. Mr. Yoshida begins the lesson by reviewing the conclusion of the previous day's lesson. He notes that they had been working with "the relationship between parallel lines" and had ended by doing some problems. "Do you remember what they were?" he asks. There is no response, so he asks the students to get out the worksheet and look again at the first problem,

which asked them to find the measure of the angle marked with an "x" in the drawing below. "We hurried through this problem," he says, "and were not able to summarize it well." Several solution methods had been presented, but briefly, and Mr. Yoshida asks the students to look again at the problem and finish it "with the method you think is easiest. . . . If you can give an explanation, that would be terrific."



After two minutes, he asks the students to present what they have found. Three different methods are presented by students, all based on drawing an additional line segment. In some cases, a triangle is formed and students then use what they already know about measures of triangles to find the measure of angle x. After each presentation, Mr. Yoshida asks how many students used that procedure. He concludes this ten-minute segment by summarizing each of the three methods, pointing out the usefulness of drawing additional lines when finding the measures of some angles.

Presenting the Problem for the Day. The lesson continues with the problem for the day.

Mr. Yoshida: Today, the problems cannot be solved without auxiliary lines. We want to do problems of this kind. The way the previous problem was made was to bend once between the parallel lines. Today, by changing this condition, I want you to make up your own problems. We won't change the parallel lines but how the angles look in the middle.

Mochida: Outside?

Mr. Yoshida: Oh, it's okay to go outside the lines. It is even okay to bend twice. I don't want you to bend ten times.

Students: (Laughter)

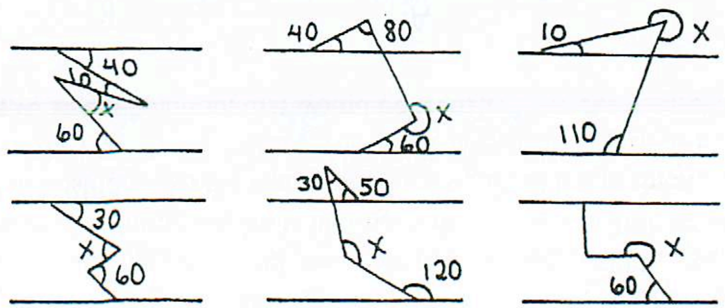
Mr. Yoshida: Twice or three times, that's the limit. After that, nobody will understand it. . . . Be creative. . . . One problem is okay, but if it's easy, do two problems. . . . Put in the angles by yourselves and write which angle is x. . . . It's pretty hard to put in the degrees. You can't just put in any degrees. . . . When you turn it in, you must be able to solve it. If people say they do not understand it, you must be able to explain it. Please think about it to the best of your abilities.

Working on the Problem Individually. As in the German lesson, the teacher presents a problem to the students that is mathematically challenging for eighth-graders. What is different is that Mr. Yoshida now asks the students to work out the solutions on their own rather than leading the class in developing the solution. Of course, students already have learned some methods that will help them get started.

For the next ten minutes, the students work individually on

constructing a problem for their peers to solve and on making sure they can solve it themselves. Mr. Yoshida circulates around the room, answering questions and giving hints. He appears increasingly concerned that students are not making more progress and finally says, "Well, it seems it was a little hard. I made a mistake. There are many of you that are in trouble. . . . Get in your groups, and from the problems you have made, pick a problem you and the others think is challenging, and group leaders please bring them up. Please check if the problem really can be solved and then bring it up."

Working on the Problem in Groups. As the students rearrange their desks, they move around the room and joke with one another about how hard the problems are that they have constructed. The noise gradually subsides, and after about two minutes, the leaders of the groups begin bringing up their problems for Mr. Yoshida to diagram on the chalkboard. After Mr. Yoshida records one problem for each of the six groups (see the diagrams below), he says, "These are the problems. We don't know whether we can solve them or not until we try. . . . It seems impossible to do all of them in this lesson, so we'll think about them a little next time, too. Please hurry and copy the six problems."



As students copy the problems, Mr. Yoshida walks around the room, observing students' work and commenting periodically about how difficult the students have made some of the problems. It soon becomes apparent that the students are trying to solve the problems as they copy them. Mr. Yoshida might have intended this, and he certainly does not discourage it. The students are still sitting in their groups; some are working together as a group, some are working in pairs, and some are working individually. After about ten minutes, Mr. Yoshida asks how many students have solved each of the problems. He then continues to circulate around the room, mostly observing as students continue to work.

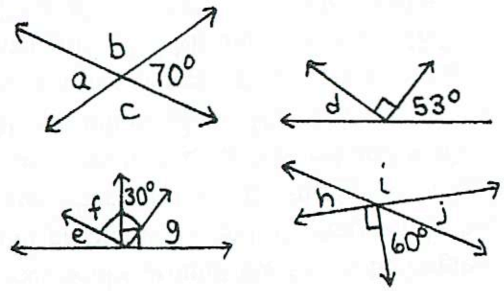
Students have been working at their seats, either individually or in small groups, for about twenty minutes now, an unusually long segment of seatwork for a Japanese lesson, and they will continue in this way for another nine minutes. As the students continue to work, they occasionally raise their hands and ask Mr. Yoshida to look at what they have done. It is apparent that some students become excited at finding solutions to the problems that Mr. Yoshida identified as being especially difficult. Mr. Yoshida studies their solutions but refuses to comment on whether they are correct.

Summarizing the Main Point. The period is almost over, and Mr. Yoshida interrupts to say, "I know this is bothersome, but I want to know the present situation." He then asks how many students have solved each problem. He concludes the lesson by observing, "There are a lot of people who are using triangles. That's okay, but there are three types of auxiliary lines. Sometimes there are easier methods of solving these problems using other types of auxiliary lines. We will check these in the next period." His brief summary is more compressed than is

typical for a Japanese lesson. The bell has already rung, forty-nine minutes after the lesson began (near average for a Japanese lesson), and the students now push their chairs back, stand, and bow.

A U.S. Lesson: Learning Terms and Practicing Procedures

Warming Up. The video begins with Mr. Jones, the teacher, conducting a "warm-up" activity. He points to the top left-hand drawing on the chalkboard (shown below).



Mr. Jones: What is the angle vertical to the seventy-degree angle? *(Pause)* John?

John: I don't know.

Mr. Jones: Don't get nervous *(apparently referring to the presence of the video camera)*. When I intersect lines I get vertical angles. Right? Look at your definitions. I gave them to you. You can look them up. Here we have vertical angles and supplementary angles. Angle A is vertical to which angle?

Students: Seventy (in chorus).

Mr. Jones: Therefore angle A must be?

Students: Seventy degrees (in chorus).

Mr. Jones: Seventy degrees. Go from there. Now you have supplementary angles, don't you? What angle is supplementary to angle B?

Checking Homework. After five minutes of this quick-paced review, Mr. Jones asks the students to "get out the worksheet I gave earlier in the week and make sure we understand complementary, supplementary, and angle measurements." The class goes over the worksheet in a similar way: Mr. Jones asks students for answers and continues questioning them until they give the correct answer. The class checks thirty-six problems on the worksheet during six minutes of question-and-answer interaction.

Demonstrating Procedures. Reviewing previous work by checking homework is reminiscent of the German lesson. But the next activity is quite different from both the German and the Japanese lessons. Rather than presenting a topic or problem for the day, Mr. Jones distributes a worksheet that contains problems that, he notes, are "just like the warm-up." At the top of the worksheet is a sample problem with the solution and a suggested method shown. Mr. Jones takes a minute to go over this with the students and then asks if there are any questions. There are none, and the students begin working independently.

Practicing the Procedures. The worksheet contains forty problems, and the students spend the next eleven minutes working on them. The problems, like the homework and the warm-up, emphasize terms and procedures—in this case, finding the measures of complementary, supplementary, and vertical angles. Mr. Jones circulates around the room, answering questions and giving hints.

The lesson clearly has taken a different turn from those in Germany and Japan. The mathematics is quite simple compared with that found in the previous two lessons. But more than that, the teaching method is different. In the German lesson, the teacher led the students through the development of some advanced mathematical procedures. In the U.S. lesson, the development is limited to a quick demonstration. As in the Japanese lesson, students in the U.S. classroom spend the heart of the lesson working on assigned problems. But American students are asked to practice the demonstrated procedures on many simple problems rather than to develop procedures for solving a few challenging problems.

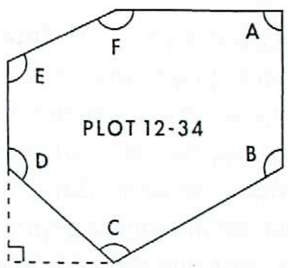
As Mr. Jones walks around the room, he begins receiving questions about problems 37 and 38. Apparently believing he should intervene when students are struggling or become confused, Mr. Jones goes to the chalkboard and works these two problems with the whole class. He begins with problem 38: "Write an equation that represents the sentence: The product of 12 and a number K is 192." Mr. Jones writes "12K" on the board and asks students what to write next. One student says "Equal sign," and Mr. Jones completes the equation: "12K = 192."

It might strike the reader as curious that this task has nothing to do with the day's lesson (calculating the measures of angles), but some American curriculum materials include review of earlier topics in later problem sets. In fact, it is not uncommon to find this kind of topic switch during U.S. lessons.

The discussion then turns to problem 37: "Angle QRS has the same measure as its supplement. Find m < QRS." Mr. Jones shows that the answer must be 90 degrees. Even these two problems, which were perceived to be the most difficult

on the worksheet, are quite simple compared with those encountered by the German and Japanese students.

Demonstrating More Procedures. Mr. Jones gives the students two more minutes to finish the worksheet and then asks them to get out the worksheet they completed the previous Friday, after a quiz. One of the problems asked students to measure the interior angles of a hexagon (shown below) and compute the total. Mr. Jones asks if everyone got an answer close to 720 degrees. He then proceeds to the second part of the problem.



Mr. Jones: If I took this angle (D) and moved it down here, and made it across this way *(see dotted lines in drawing)*, moved D down here, should that change the sum, the total?

Jason: No. *(Other students repeat this answer.)*

Mr. Jones: It should not. Why? I still have how many angles?

Obed: You still have six.

(It must be noted here that, based on what students have studied to this point, there is no way they can know the answer to

Mr. Jones's opening question, or that the number of angles is the crucial fact in finding the sum of the angle measures. But the nature and tone of teachers' questions often give away the answer, and a number of students apparently picked up on these cues and answered the questions appropriately.)

Mr. Jones: I still have six angles. There is a formula, and we are going to go through this after spring break, but I will give you a hint right now. If I take the number of sides, and I subtract two, and I multiply that number times one hundred eighty degrees, that will tell me how many degrees these add up to. How many sides in this figure? *(Pause).* Six. Right? Number of sides subtract two, gives me what?

Students: Four.

Mr. Jones: Four. What is four times one hundred eighty degrees?

Jacquille: Seven hundred twenty.

Mr. Jones: Should be seven hundred twenty, right? How many degrees should there be in a five-sided figure? *(Pause).* Take the formula; the number of sides is five . . . subtract two, and multiply by one hundred eighty degrees.

Mike: Five hundred ninety?

Mr. Jones: Five hundred forty degrees. All five-sided figures contain five hundred forty degrees.

By giving the students this formula, Mr. Jones has just taken a problem that could have been challenging for the students (at a level similar to that in Germany and Japan) and changed it into a routine problem for which they must simply follow a rule. One of the features that make this lesson typical of teaching in the United States is just this: stating rules, rather than developing procedures, and thereby turning mathematics into a matter of following rules and practicing procedures.

Reviewing Procedures and Definitions. After using the formula to calculate the sum of the interior angles in a triangle, Mr. Jones makes several announcements about upcoming activities and future quizzes and tests. He then conducts a quick oral review with the class on the meaning of terms such as complementary, supplementary, obtuse angle, and acute angle. A few minutes remain, and Mr. Jones tells the students to use the time "to finish up any of this, and ask me questions." The lesson ends with a bell, forty-eight minutes after it began (about average for the United States).

Variations on a Theme

After watching these lessons, and many others like them, we developed the images of teaching, complete with mottoes, that we sketched at the beginning of this chapter. But we noted then that these images are, in many ways, too simplistic. Why? Because there is a range of lessons in each country. Many lessons look much like the ones we have described, and it is from these that the simple images were formed. But some lessons look quite different. We can form richer images of teaching by seeing the full spectrum of lessons.

German Variations: More Practice and More Student Participation

The spectrum of lessons in Germany moves out from the center in two different directions. Some lessons focus more on practicing skills already learned than does the lesson taught by Mr. Eisner; other lessons include more student exploration of concepts and procedures.

Practicing skills is illustrated by a lesson on solving linear equations. The lesson begins with the teacher reporting that the students' performance on a recent test was not very good and suggesting that more practice is needed. The teacher asks two students to come to the chalkboard, and he dictates a problem for each of them. The first problem is $(2x - 3)/3 - (3x + 4)/4 = -9/20 - (4x - 3)/5$. The rest of the students are expected to watch and correct errors as the two students work through the problems at the chalkboard. The teacher carefully monitors the step-by-step procedures of both students, often asking questions and correcting errors. After the two students finish, the teacher asks if there are questions and calls two more students to the front, dictating two new problems. The entire lesson proceeds in the same way. Some aspects of the lesson are quite typical: students working on complex procedures at the chalkboard with the teacher monitoring progress; and the teacher orchestrating a whole-class question-and-answer discussion of the solutions. But the emphasis on skills already learned, without the development of a new concept, is different from most lessons.

The second kind of variation—more student participation in developing the mathematics—is illustrated by the following lesson. The teacher begins by reviewing the main point from the previous lesson: special polygons, like squares and equilateral

triangles, are defined by special relationships and special properties of their sides, angles, and so on. The teacher then distributes cardboard models of a variety of special polygons and asks the students to find all of the special properties they can—sizes and relationships of sides and angles, and axes of symmetry. Students work together in small groups, and after about fifteen minutes group representatives come to the front, one at a time, and fill in the cells of a large chart, answering "yes" or "no" to statements such as "sides are equal," "angles are equal," and "diagonals are axes of symmetry" with respect to their polygon. One polygon, the kite, creates considerable disagreement among the students. The teacher demonstrates again how to check special properties and asks everyone to reexamine the kite.

As we put together the typical features with the variations, our image of German mathematics teaching as "developing advanced procedures" still seems appropriate. In Mr. Eisner's lesson, the procedures were methods for proving the Law of Thales, a powerful and rich theorem in geometry. The two variations can be interpreted as complements to the theme. In one case, the emphasis shifts from the initial development of procedures to proficiency of execution. In the second case, the teacher allows the students to participate more directly in the development of the procedures, at least for a short time. But the teacher is still in control, carefully constraining the task to ensure certain outcomes. Both kinds of variation support the image of the knowledgeable teacher leading students through the development of advanced mathematical procedures.

Japanese Variations: Teacher Telling and Students Memorizing

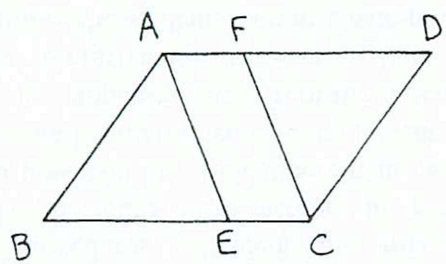
At first glance, the variations we find in Japanese lessons appear to conflict sharply with the lesson presented by Mr.

Yoshida. It is not even clear that the typical lessons and the variations fit along the same spectrum. We see teachers lecturing about a topic or telling students how to solve a problem or asking students to memorize properties or facts through repeated recitation. It is especially interesting that when these activities occur, they often are put together, in the same lesson, with students' solving problems and sharing solution methods. From an American point of view, this looks rather odd.

In one lesson, the teacher begins by identifying the new topic that will continue for several weeks—the analysis of polygons. For the next thirty-five minutes, he lectures. He talks about historical discoveries, about the prevalence of these figures in the real world, and about the fact that this topic is more closely related to the previous one—linear functions—than students might think, because both search for relationships. He concludes by posting the goal for mathematics: "To learn to think logically while searching for new properties and relationships." He asks students to repeat this goal several times and memorize it. The teacher then says that the first task will be to study relationships among angles, and he draws a large *X* on the board. He asks students to draw a similar *X* on their papers and to use a protractor to investigate the relationships among the angles. "Write down things you notice," he says. After five minutes the students share what they've found, including that the angles opposite each other are equal. The teacher wonders aloud whether this would always be true. Could it be proved? He then, with large hints, helps students discover a proof.

In another lesson, the teacher begins by reviewing three properties of parallelograms that they have developed thus far, such as "opposite sides are of equal length." He posts the three statements, and the students spend fifteen minutes reciting

them. The class recites them together, then a student stands and recites them alone, then they spend one minute reciting them quietly to themselves, and then they repeat the process. The teacher concludes this activity by saying that students need to remember the properties because they will need them. He then presents the picture shown below and says, "If ABCD is a parallelogram and BE equals DF, prove that AE equals CF." The proof, not surprisingly, uses the properties just recited, and the students are asked to develop and share several different proofs.



At first glance, these two lessons look quite different from the one taught by Mr. Yoshida. But after viewing them several times, we can see how they complement the image of "structured problem solving." When students are asked to solve challenging problems, teachers often build scaffolds to help them. The scaffolds come in many forms. Sometimes they are the outcomes of previous lessons, reviewed by the teacher (as in Mr. Yoshida's lesson). Sometimes they are in the form of information provided through lectures, and sometimes in the form of mental tools provided through memorization. What is constant is that challenging problems are selected and scaffolds are provided so that students can, at the least, begin developing methods for solution.

Not every lesson, however, fits neatly along this spectrum. In one lesson, the teacher says that today they will be talking about the solutions and graphs for simultaneous linear equations. She then leads the students through a twenty-five-minute review of graphing linear equations, showing them how they can translate any form to $y = mx + b$ and can then graph the equation easily. She then shows that when two equations are graphed on the same axes, they often intersect in one point, and this point is special—it has coordinates that satisfy both equations. Throughout the entire discussion, she asks students short-answer questions and accepts their responses, but she essentially tells the students what they need to know and how to solve the problems.

This lesson shows that "structured problem solving" does not capture the full range of Japanese instruction. Indeed, it seems that the teaching method in this lesson is more like the methods typically used in Germany than the methods typically used in Japan. If nothing else, the lesson reminds us that not all teachers within the same country use the same methods.

U.S. Variations: More Review and More Student Participation

As in Germany, the spectrum of lessons in the United States moves out from the most common in two different directions: even more review than in Mr. Jones's lesson on one side, and more student participation on the other.

In one lesson, the teacher announces that students will have time to review for the upcoming chapter test. Apparently referring to the suggestions in the teacher's manual, the teacher says, "What they said is that I shouldn't review with you; you should do it in your groups." The students begin reviewing. Although their desks are placed together in groups of four,

most students work through the textbook review page on their own, raising their hands when they have questions. The teacher circulates around the room for the full period, answering questions and briefly tutoring individual students who need help.

Another lesson, although also review, contrasts sharply in teaching method. The teacher hands back the previous day's quiz as each student enters the room. The teacher asks the students to get into their groups and compare responses, check mistakes they made, and decide to present one problem to the class that was hard for them. During most of the lesson, group representatives, in turn, present their selections on the chalkboard and lead a class discussion about methods of solution. One problem is to solve the following systems of equations: $y = 2x - 9$; $x + 2y = 2$. Another problem is to factor $8x^2 + 8$. Apparently, the teacher intends for students to present and discuss their methods, but she often jumps in to correct or explain or cut off discussion in order to move to the next problem. At the end of the lesson, the teacher reviews the slope-intercept form for linear equations and how it can be used to construct graphs, and then assigns twenty-five problems from the textbook for homework.

Both kinds of variations, in different ways, are consistent with our simplified U.S. image of "learning terms and practicing procedures." The first kind of variation—additional review—simply reinforces the theme. The second kind of variation expands the image. Although the goal of the second lesson is similar to the goal of the others—learn terms and practice procedures—the classroom activities in which the students are engaged look quite different. Working with other students to analyze problems, presenting problems to the class, describing one's own method for solving them, and asking questions of

peers—all these give students a more active role than they had in either the review lesson or Mr. Jones's classroom.

Lessons in which students participate in this way might show the effects of the current reform efforts. There are, however, very few of these lessons, and when they do occur, the variations from the theme appear in the *form* of activities, not the substance. Students are seen working in small groups or engaging in a discussion about solution methods, but the mathematics is simple compared with that encountered by their German and Japanese peers, and the work and discussion are mostly about memorizing definitions for terms and following rules and procedures.

Can We Trust the Images?

Portraits of individual lessons are useful when they create images of teaching that represent the way teaching actually looks. But they can be dangerous if they misrepresent the situation. It is wise to be skeptical when deciding whether the description of a few lessons creates a fair image of teaching in each country. This is especially true when dealing with activities as complex as classroom teaching.

Of course, we presented these typical lessons because we believe that they *are* useful. They capture quite well the images of teaching that we formed while watching the tapes and discussing them with our colleagues, and we believe they are a fair representation of teaching in each country. But as we stated at the end of Chapter 2, both impressionistic reports and coded data are necessary for learning about teaching. By examining the coded data from the lessons, readers can

check the claims we made about what is typical in each country. The coded data also help to refine these images of teaching. In the next chapter, we present this information and then come to some fundamental conclusions about the nature of teaching, regardless of what it looks like or where you find it.